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INSTRUCTION MANUAL
FOR
DANA* MODEL 2720
GALVO-DRIVER AMPLIFIER

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December - 1965

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TABLE OF CONTENTS

Section	Title	Page
1	GENERAL INFORMATION	1-1
	1.1 DESCRIPTION	1-1
	1.2 SPECIFICATIONS	1-2
2	INSTALLATION AND CHECKOUT	2-1
	2.1 UNPACKING AND INSPECTION	2-1
	2.2 INSTALLATION AND INPUT-OUTPUT CONNECTION	2-1
	2.3 CHECKOUT PROCEDURE	2-4
3	OPERATING INSTRUCTIONS	3-1
	3.1 GAIN CONTROL	3-1
	3.2 ZERO ADJUSTMENT (ELECTRICAL)	3-2
	3.3 ZERO ADJUSTMENT (MECHANICAL)	3-2
	3.4 NORMAL-REVERSE SELECTION	3-2
	3.5 OUTPUT CURRENT LIMIT ADJUST	3-2
	3.6 PADDING RESISTANCE	3-2
4	PRINCIPLES OF OPERATION	4-1
	4.1 INTRODUCTION	4-1
	4.2 OPERATIONAL DESCRIPTION	4-1
	4.3 CIRCUIT DESCRIPTION	4-1
	4.4 SWITCH ASSEMBLY	4-3
5	TROUBLESHOOTING AND MAINTENANCE	5-1
	5.1 TROUBLESHOOTING	5-1
6	SCHEMATICS	6-1

ILLUSTRATIONS

Figure	Title	Page
2.1	Wiring Instructions - Model 3008-1 Enclosure . .	2-2
2.2	Wiring Instructions - Model 3008-2 Enclosure	2-3
3.1	Galvo-Driver Amplifier - Model 2720	3-1
3.2	Two-Resistor Net For Damping Galvanometer . .	3-3
3.3	Padding Resistors - Physical Location	3-3
4.1	Model 2720 Block Diagram	4-2
6.1	Model 2720 Schematic	6-2
6.2	Model 2720 Board Assembly	6-3
6.3	Model 2720 Switch Assembly	6-4
6.4	Dimension Outline - 3000 Series (-1) Enclosure .	6-5

1. GENERAL INFORMATION

1.1 DESCRIPTION

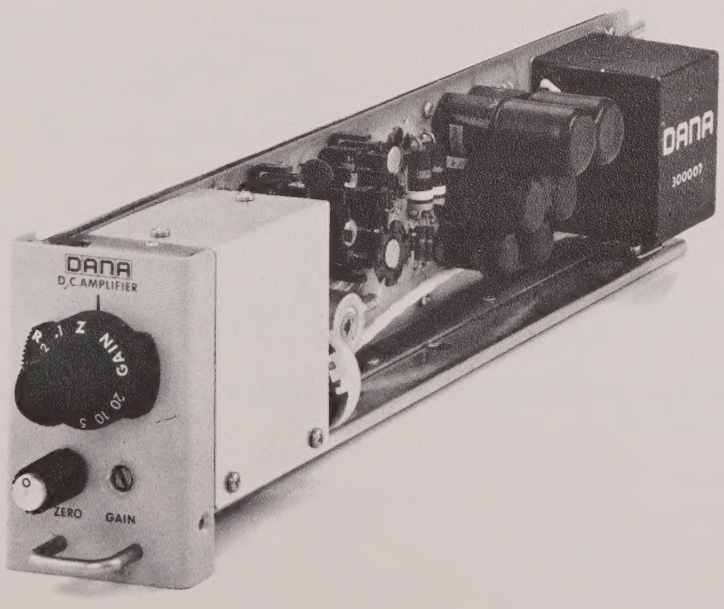
The Dana Model 2720 is an all solid state, three-terminal floating DC amplifier with integral power supply. It provides a high degree of isolation from case or power ground.

The unit is designed for use as a preamplifier for oscillographic recorders and for driving loads requiring currents up to 100ma.

The amplifier features gain continuously variable from .1 to 50 with zero position, voltage limiting and variable current limiting for galvanometer protection, and a reversing switch which reverses or shorts the output leads. Excellent linearity and distortion, wide bandwidth and fast overload recovery add to its versatility.

Extreme reliability and long life stem from the basic design. Mechanical choppers and other moving parts have been eliminated. New design concepts have resulted in simplified circuits that minimize the total number of components. Silicon semiconductors are used exclusively. The internal circuitry is contained on a single printed circuit board which mounts to the amplifier chassis.

There are four front panel controls used in operation: a gain selector switch, an output reversing or shorting switch, a recessed vernier gain control, and a full-scale zero adjustment.



1.2 SPECIFICATIONS

Output (panel switch reverses or shorts output leads)

Full scale	±10 volts, 100 ma
Linear overrange, nominal	20%
Impedance (maximum)	0.1 ohm dc 1 ohm dc to 2 kc 5 ohms dc to 10 kc
Capacitive load	1 microfarad, without instability
Limiting protection (short circuit will not damage amplifier)	
Voltage	±13 volts peak
Current	Variable, 35 ma to 150 ma
Frequency response	
DC to 2 kc	±1% at full output
DC to 10 kc	±2% at full output
DC to 20 kc	±5% at full output
DC to 50 kc	-3db at 10% of full scale
Phase shift, dc to 400 cps	1 degree, maximum
Distortion (at full output)	0.05% maximum at 1 kc
Linearity (at full output)	
DC	0.02%
AC to 3 kc	0.1%
Gain	
Fixed steps	Zero*, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20
Accuracy	±0.5%
Stability	±0.1%
Vernier	Varies gain up to 2-1/2 times fixed step
Noise, referred to input at gain of 20	25 microvolts RMS, full bandwidth

* Zero position shorts amplifier input to common; leaves 100 k connected across source.

SPECIFICATIONS - (Cont)

Step function settling time	50μsec to 0.5% of full scale
Overload recovery (from 500% overload)	200μsec to 0.5% of full scale
Zero drift (with up to 1k source, after 30 minute warmup)	
Constant temperature, 40 hours	±0.02% of full scale ±0.1% of zero offset
Per °C	±0.03% of full scale ±0.05% of zero offset
Zero control (front panel)	±100% of full scale
Input impedance	100 kilohms
Fault protection	Up to 20 volts normal mode will cause no damage. Up to 250 volts, amplifier common to case or power ground, will cause no damage.
Isolation, any terminal to case or power ground	At least 10^8 ohms in parallel with less than 500 pf
Power requirements	105 - 125 volts, 50 to 400 cps, 5 watts
Weight	4 lbs
Units per Dana Model 3008 enclosure	8

*

2. INSTALLATION AND CHECKOUT

2.1 UNPACKING AND INSPECTION

The Dana Amplifier is shipped in a special shipping package, designed to protect the instrument from excessive shock and vibration.

Examine the package for signs of external damage before removing the unit. If external damage is present, notify the carrier before proceeding.

Next, examine the outside of the amplifier for any evidence of damage due to excessive shock, vibration, water leakage, etc. If there is no visual external damage, remove from the enclosure and check physical condition of the circuit boards and components.

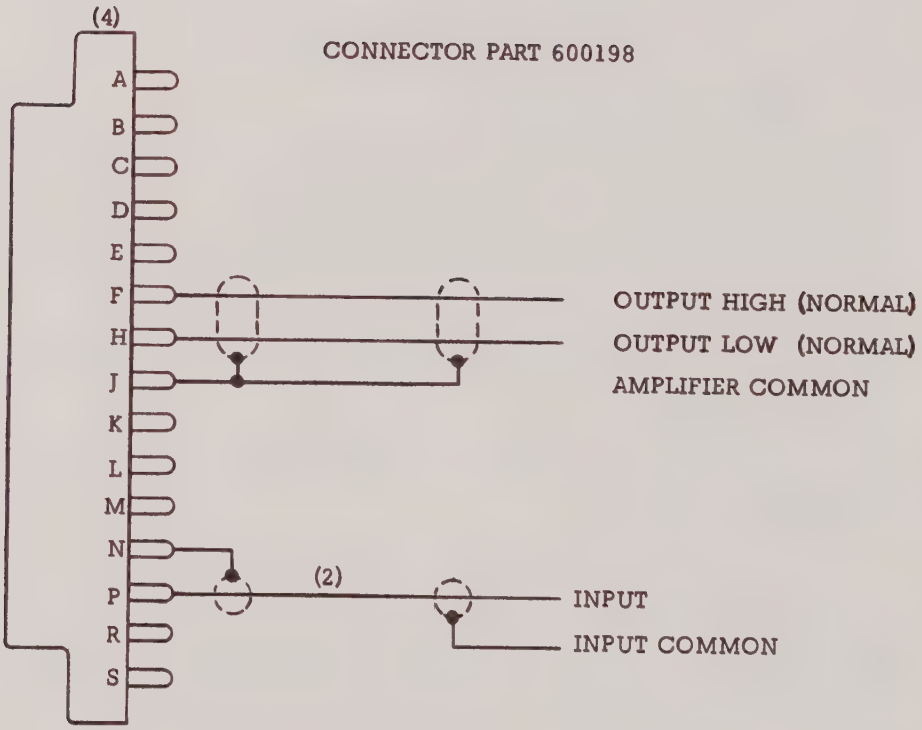
If the unit appears in perfect condition, perform the checkout operation described in Section 2.3. However, if there is any apparent damage communicate with the carrier for instructions.

2.2 INSTALLATION AND INPUT-OUTPUT CONNECTION

The Model 2720 amplifier is normally mounted with eight units to a standard Dana Model 3008-1 or 3008-2 rack enclosure. The enclosure 3008-2 is prewired to interconnect the individual amplifiers with the connectors on the back panel. Refer to the rack wiring diagrams shown in Figure 2.1 and 2.2.

The amplifier input-output connections are as follows:

	TERMINAL	WITHOUT PADDING RESISTORS	WITH PADDING RESISTORS
Key	A	AC POWER GROUND	AC POWER GROUND
	B	AC POWER (HIGH)	AC POWER (HIGH)
	C	AC POWER (LOW)	AC POWER (LOW)
Key	D	AC POWER GROUND	AC POWER GROUND
	E	AC POWER GROUND	AC POWER GROUND
	F	OUTPUT LOW SIDE (IN NORMAL)	OUTPUT LOW SIDE (IN NORMAL)
	H	OUTPUT HIGH SIDE (IN NORMAL)	PADDED OUTPUT (HIGH SIDE)
	J	OUTPUT SHIELD (AMPLIFIER COMMON)	OUTPUT SHIELD (AMPLIFIER COMMON)
	K	NOT USED	
	L	COMMON TO PIN N	COMMON TO PIN N
	M	COMMON TO PIN N	COMMON TO PIN N
	N	INPUT LOW SIDE	INPUT LOW SIDE
	P	INPUT HIGH SIDE	INPUT HIGH SIDE
	R	COMMON TO PIN N	COMMON TO PIN N
	S	COMMON TO PIN N	COMMON TO PIN N



Notes:

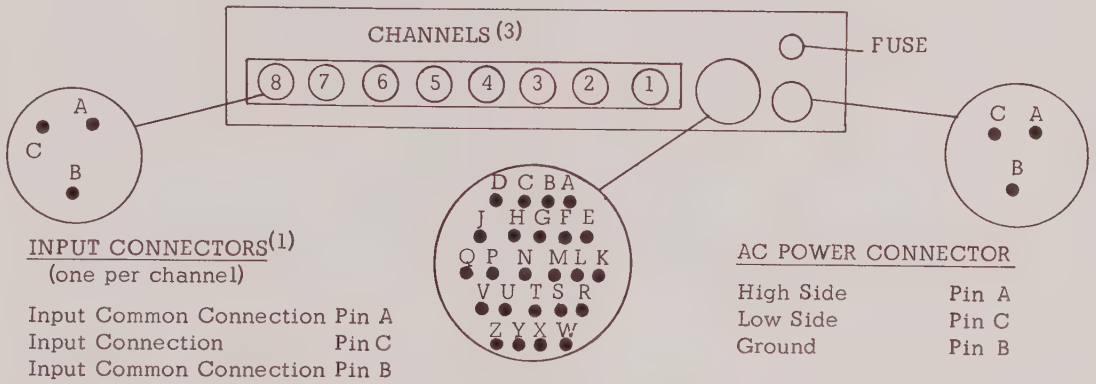
1 The above leads are installed by user. All other wiring is factory installed.

2 Use one conductor shield. If two conductor is used, connect one lead to pin P, the other to pin N and shield to pin M (pins L, M, R, and S are common to pin N).

3 Use two conductor shielded twisted pair. Tie shield to pin J at rack and leave shield unterminated at load end.

4 Connector located at the rear of rack for each amplifier channel.

Figure 2.1 - Wiring Instructions — Model 3008-1 Enclosure



INPUT CONNECTORS(1)
(one per channel)

Input Common Connection Pin A
Input Connection Pin C
Input Common Connection Pin B

AC POWER CONNECTOR

High Side	Pin A
Low Side	Pin C
Ground	Pin B

Output Connections (2)

Model 3008-2

Channel	Output High (Normal)	Output Low (Normal)	Shield
1	E	F	A
2	B	C	G
3	H	J	D
4	K	L	R
5	M	N	T
6	P	Q	V
7	W	X	S
8	Y	Z	U

NOTES: (1) Use coaxial cable for input leads. Connect center conductor to INPUT (PIN C) and shield to INPUT COMMON (PIN A).

(2) Use shielded 2 conductor cable for output leads. Cable shield ties to SHIELD pin connection at rack end and should be left unterminated at load end.

(3) Viewing enclosure from the front, amplifiers are numbered from left to right.

	Mating Connector and Clamps	Dana Part Number
INPUT	3106 A-10 S1-3S A105-A115	601561
(8 sets required)	3057-4A-A105 w/Bush	601474
OUTPUT	3106 A-24-28P-639	601563
(1 set required)	3057-16A-639 w/Bush	601564
AC POWER	3106 B-14S-7S-639	601640
(1 set required)	3057-6A-639 w/Bush	601639

Figure 2.2 - Wiring Instructions — Model 3008-2 Enclosure

2.2.1 POWER CONNECTIONS

The amplifier has a self-contained power supply which is operated from the AC line. Single-phase, 115V rms, 50 to 400 cps power is required. A three-wire line cord should be used with a standard three-prong connector. The third wire is used to ground shields internal to the power supplies. Do not apply power until all other elements in the test setup are connected. If the unit is to be operated on the bench, care must be taken to see that the mating connector is properly keyed in accordance with the above table, Section 2.2. If the ends of the mating connector are inverted, damage can be inflicted to the amplifier.

2.2.2 INPUT TERMINALS

The input consists of two terminals, P and N. The high side of the input should be connected to P and the low side to N.

2.2.3 OUTPUT TERMINALS

The output normally consists of three terminals, F, H, and J. When padding resistors are used (Section 3.6) a direct output, by passing the resistors, may be obtained at pin K.

When the output reversing switch is in NORMAL, pin H or K is output high side and pin F is output low side (connects to input low side). When the output reversing switch is in REVERSE, pin F is output high side and pin H or K is output low side (connects to input low side). Pin J connects to amplifier common (input low side) regardless of the position of the reversing switch.

It is recommended that the output cable be two conductor shielded. The inner conductors should be connected to pins H or K and F at the amplifier output terminals and to the load at the load end of the cable. The shield should be connected to pin J at the amplifier terminals and should be un-terminated at the load end of the cable.

2.3 CHECKOUT PROCEDURE

The simple tests described in this section are generally sufficient to check out the instrument on receipt. The purpose of these tests is only to establish that the amplifier is in operating condition. The procedure should not be confused with the more elaborate specification checks which the user may want to perform before he actually puts the amplifier into use.

Only three pieces of test equipment are required to conduct checkout tests:

Audio Oscillator
Voltage Divider/Attenuator
Oscilloscope

Standard laboratory-type instruments from any manufacturer may be used.

2.3.1 GAIN

First step is to ground the oscillator, voltage divider, oscilloscope and amplifier input low side. To accomplish this, connect the common or ground terminal of each instrument to a single point, then connect this point to ground. All measurements are made relative to this point.

Next, connect the oscillator output to the input of the voltage divider. Then connect the output of the divider to the amplifier input P lead. Connect the amplifier output high side (Normal) to the oscilloscope input. (Set output reversing switch to Normal.)

Set the voltage divider to minimum output, zero if possible. Then plug the amplifier into the power source.

Then output from the amplifier, as indicated by the oscilloscope trace, should be within a few millivolts of ground, and should change only very slightly as the gain setting on the front of the amplifier is changed. Turn the vernier gain control to minimum (extreme counterclockwise). Then set the gain knob at maximum (gain of 20).

Disconnect the oscilloscope input from the amplifier OUTPUT and connect the oscilloscope to the oscillator output. Adjust the oscillator to 20 volts, peak to peak at 100 cps or any other convenient low frequency. Set the voltage divider at the reciprocal of the maximum amplifier gain setting, or .05. Now return the oscilloscope input to the amplifier OUTPUT. The oscilloscope should indicate approximately the same value, 20 volts, as when connected directly to the oscillator. The term "approximately" is used because of limited capability of an oscilloscope to compare two magnitudes accurately.

There should be no obvious noise or other unexplained distortions in the oscilloscope trace.

3. OPERATING INSTRUCTIONS

3.1 GAIN CONTROL

Gain is set by the combination of a front panel multiposition switch and a front panel vernier control (see Figure 3.1). The switch has fixed gain settings of .1, .2, .5, 1, 2, 5, 10, and 20. (The Z position on this switch shorts the amplifier input leads to facilitate the electrical zero adjustment described below.)

The vernier gain control is set to the fixed gain setting by turning it to the extreme counterclockwise position. Gain is increased up to 2-1/2 times the fixed position (overlapping the next higher fixed position) by turning the knob to the extreme clockwise position.

The combination allows the amplifier to be set to any gain value between .1 and 50.

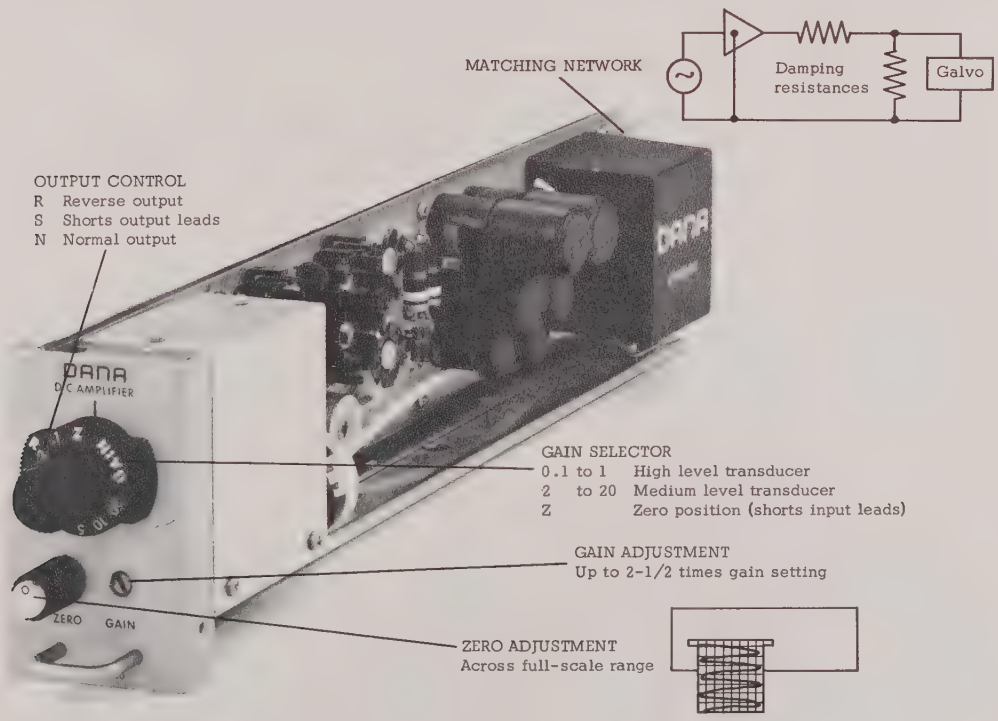


Figure 3.1 - Galvo-Driver Amplifier - Model 2720

3.2 ZERO ADJUSTMENT (ELECTRICAL)

To electrically adjust the zero point of the galvanometer trace, the front panel zero-adjustment knob is turned clockwise or counterclockwise. A full scale excursion in either direction is possible. If it is desirable to make this adjustment with zero input to the amplifier (input leads shorted), the gain switch should be turned to the "2" position.

3.3 ZERO ADJUSTMENT (MECHANICAL)

To provide a coarse mechanical adjustment of the galvanometer trace, the N-S-R switch (concentric with the gain switch) is set to the S "shorting" position. This shorts the galvanometer input leads and allows the galvanometer zero point to be mechanically shifted to approximately the desired position. Normally this operation is followed by a more refined electrical zero adjustment.

3.4 NORMAL-REVERSE SELECTION

The output may be reversed by turning the N-S-R switch from the N "normal" position to the R "reverse" position. The effect is to reverse the low side and high side assignments of output pins F and H (padded) or K (non-padded).

3.5 OUTPUT CURRENT LIMIT ADJUST

Although the output short circuit current is set at the factory for $\pm$150 ma, it may be desirable to limit the output current to a lesser value to afford galvanometer protection. Potentiometers R-18 and R-17, located on the printed circuit board (Part 400476), vary the output short circuit current from 50 ma to 150 ma. A voltage limit (at the output) of $\pm$13V DC or peak AC provides an additional degree of protection to the load.

3.6 PADDING RESISTANCE

Provision is made to add resistors to the output circuit so that the full scale of the galvanometer will corrent with the amplifier full scale and provide the damping resistance called for in the galvanometer specifications.

Padding resistors in series with the galvanometer are connected across the R_A pad (see Drawing 430280); resistors in parallel with the galvanometer are connected across the R_B pad.

4. PRINCIPLES OF OPERATION

4.1 INTRODUCTION

The Dana Model 2720 is an all solid state, wideband, non-inverting DC amplifier with integral power supply. Direct coupled solid state circuitry with silicon transistors is used exclusively. Modulators, mechanical or otherwise, are not used.

4.2 OPERATIONAL DESCRIPTION

The unit is a three-terminal floating amplifier (see Figure 4.1). A single-ended potentiometric amplifier with a closed loop gain of 30 follows a 100 kilohms input divider with attenuation ratios of from 1/300 to 2/3 to provide an overall gain of .1 to 20.

The low side of the input and the low side of the output both tie internally to amplifier common. Amplifier common, as well as the rest of the amplifier circuitry, is isolated from case and power ground. This allows the amplifier to be operated in a floating configuration when either the load or source is ungrounded.

4.3 CIRCUIT DESCRIPTION

The basic open look amplifier is differential input and single-ended output. The power supply has two isolated sections. The section supplying $\pm$20 volts is a zener diode series regulated supply. The portion supplying $\pm$100 ma is a full wave bridge rectifier with capacitive filters.

The first stage (Q_{11A}, Q_{11b}, Q_{12}) is a balanced differential amplifier and current generator which amplifies the difference signal at its bases and feeds the second stage differential amplifier (Q_{10A}, Q_{10B}). An emitter follower (Q_9) off the collector of Q_{10A} provides current gain to the driver stage (Q_7, Q_8) and minor loop roll-off (R_{25}, C_{14}). R_{27} and C_{15} roll off forward gain in the minor loop, while R_{31} and C_{17} preserve minor loop roll off symmetry. A class AB output stage (Q3, Q4, Q5, Q6) is employed to eliminate crossover distortion. The output roll off capacitor (C8) allows an output loop to be closed through C10. R37 is a factory selected resistor which supplies base current to Q_{11A}. R-17 and R-18 adjust the plus (+) and minus (-) short circuit current limits, while CR-22 and CR-23 limit the output voltage swing to $\pm$13 volts. R-38 allows the gain vernier zero shift to be set to zero.

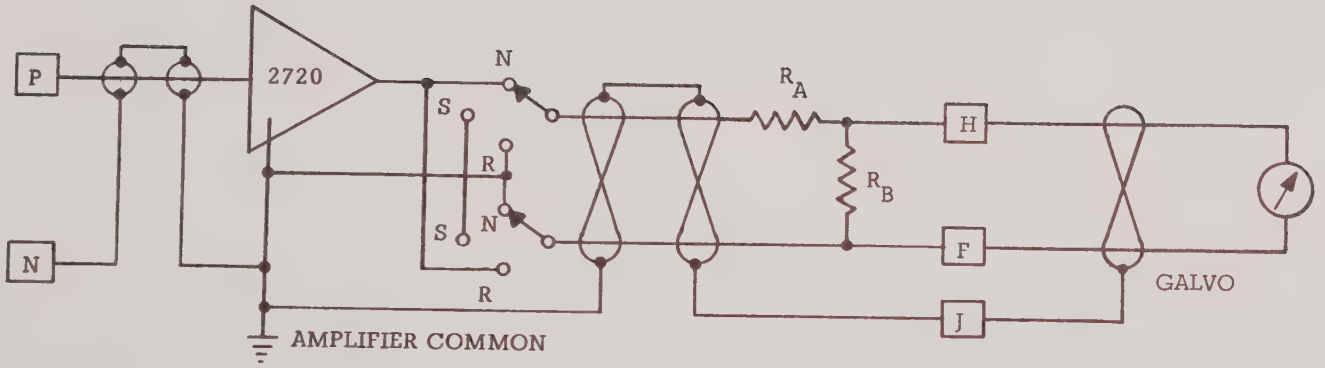


Figure 4.1 - Model 2720 Block Diagram

4.4 SWITCH ASSEMBLY

The switch section contains the attenuator and gain resistors, output switch, gain selector switch, vernier gain control and full scale zero adjustment.

A potentiometric gain of 30 is provided through the feedback gain resistors (R40, R44 and R42), when the gain vernier potentiometer (R43) is in the full counter-clockwise position (S3 connects to R42). When the gain vernier control is rotated clockwise, S3 connects to R43 and the gain can be increased up to 2.5 to 1. Output switch (S2A, S2B) provides normal, reversed, or shorted output leads to the load. Short position is extremely useful when mechanically zeroing a galvanometer.

Attenuator resistors (R45 through R53) and gain selector switch (S1) provide a constant input impedance of 100 kilohms and attenuation ratios of 1/300 to 2/3. These ratios, times the closed loop fixed gain of 30, yield overall gains of .1 to 20. When the gain selector switch is in the zero position, the 100 kilohms input resistance remains across the input terminals of the amplifier and the input to the potentiometric amplifier is shorted to input common. This allows the output of the amplifier to be adjusted anywhere from +10 volts to -10 volts, independent of the gain switch or vernier gain control, by means of the zero potentiometer (R39).

5. TROUBLESHOOTING AND MAINTENANCE

Basic new design concepts in the Dana Model 2720 amplifier simplified circuit that minimizes the total number of components, eliminates mechanical choppers and their moving parts, and affords maximum reliability and long life through the exclusive use of silicon semiconductors.

5.1 TROUBLESHOOTING

The first step in troubleshooting the amplifier is to see if all inputs (power and signal) are present. Next is to check the DC supply voltages. The two series regulated supplies should provide plus and minus 20 volts (±2 volts) at about 10 millivolts peak-to-peak ripple.

Because of the difficulty in signal tracing a closed loop amplifier (any error will appear throughout the loop) it is often more simple to troubleshoot with resistance measurements for each component (e.g., transistors and diodes). If the user wishes to troubleshoot dynamically, he may break the loop by setting the gain switch to Z; adjusting the zero potentiometer (R39) to approximately 0 volts at the wiper, and jumpering point (N) to ground. By moving R38 from full cw to full ccw, the output should go through zero. Due to the high open loop gain, the output may appear noisy. By properly biasing each stage to the positive side and then to the negative side, the output should pass through zero. However, this should be done by experienced technicians as more damage may result if the transistors or diodes are overlooked.

When padding resistors are used, the output lead normally soldered to the amplifier side of terminal H should be disconnected and soldered to terminal T. (See pin assignments in Section 2.2 above for the effect this change has on the output pin assignments.)

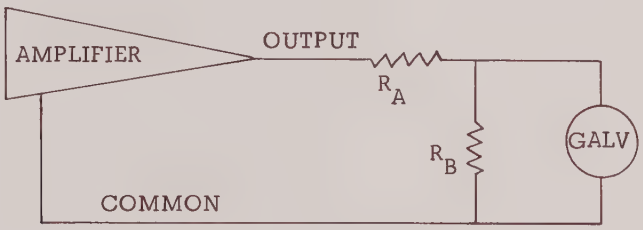


Figure 5-1. Two-Resistor Network for Damping Galvanometer

Values for R_A and R_B are defined by:

$$R_A = \frac{10V}{I_{FS}\left(1 + \frac{R_g}{R_d}\right)}$$

and

$$R_B = \frac{R_A \, R_d}{R_A - R_d}$$

Where: R_d = Required External Damping Resistance

R_g = Galvanometer Resistance

I_{FS} = Galvanometer Full Scale Current

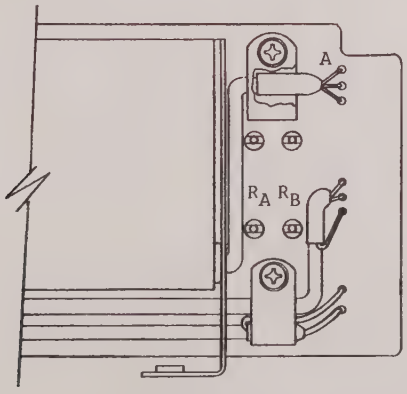


Figure 5.2 - Padding Resistors - Physical Location

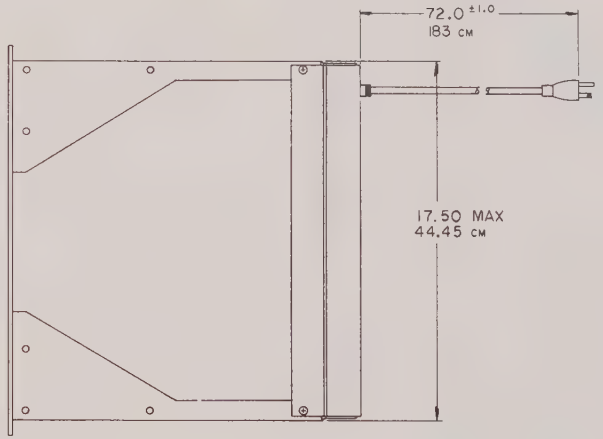
6. SCHEMATICS

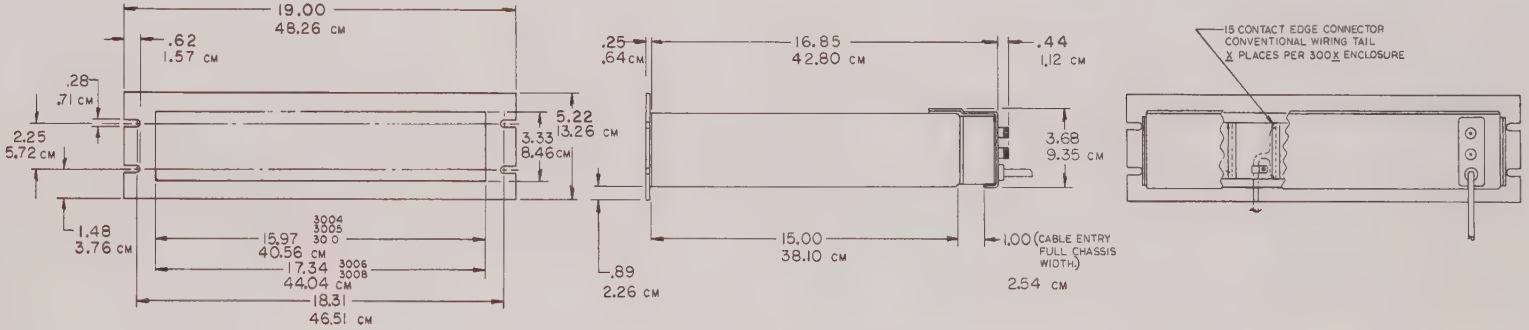
Figure 6.1 - Schematic - Model 2720

Figure 6.2 - Board Assembly - Model 2720

Figure 6.3 - Switch Assembly - Model 2720

Figure 6.4 - Dimension Outline -
3000 Series (-1) Enclosure





QTY REQD	SYM	ITEM NO.	GOV'T IDENT NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	SPECIFICATION
					LIST OF MATERIALS OR PARTS LIST	

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

SYMBOLS
APPLICABLE TO DANA LABORATORIES INC. ONLY
SA—SUB—ASSY NRA—MAJOR REPL. ASSY
MA—MODULE ASSY CA—COMPLETE ASSY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS X ± .030, XX ± .020, XXX ± .010
ANGLES ± 0° 30'

MATERIAL
APPLIED FINISH

DRAWN L. Donald 10/14/65
CHECK W. Trench 10/26/65
ENGR
APPR
APPROVED
APPROVED

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

DIMENSION OUTLINE—
3000 SERIES
(-1) ENCLOSURE

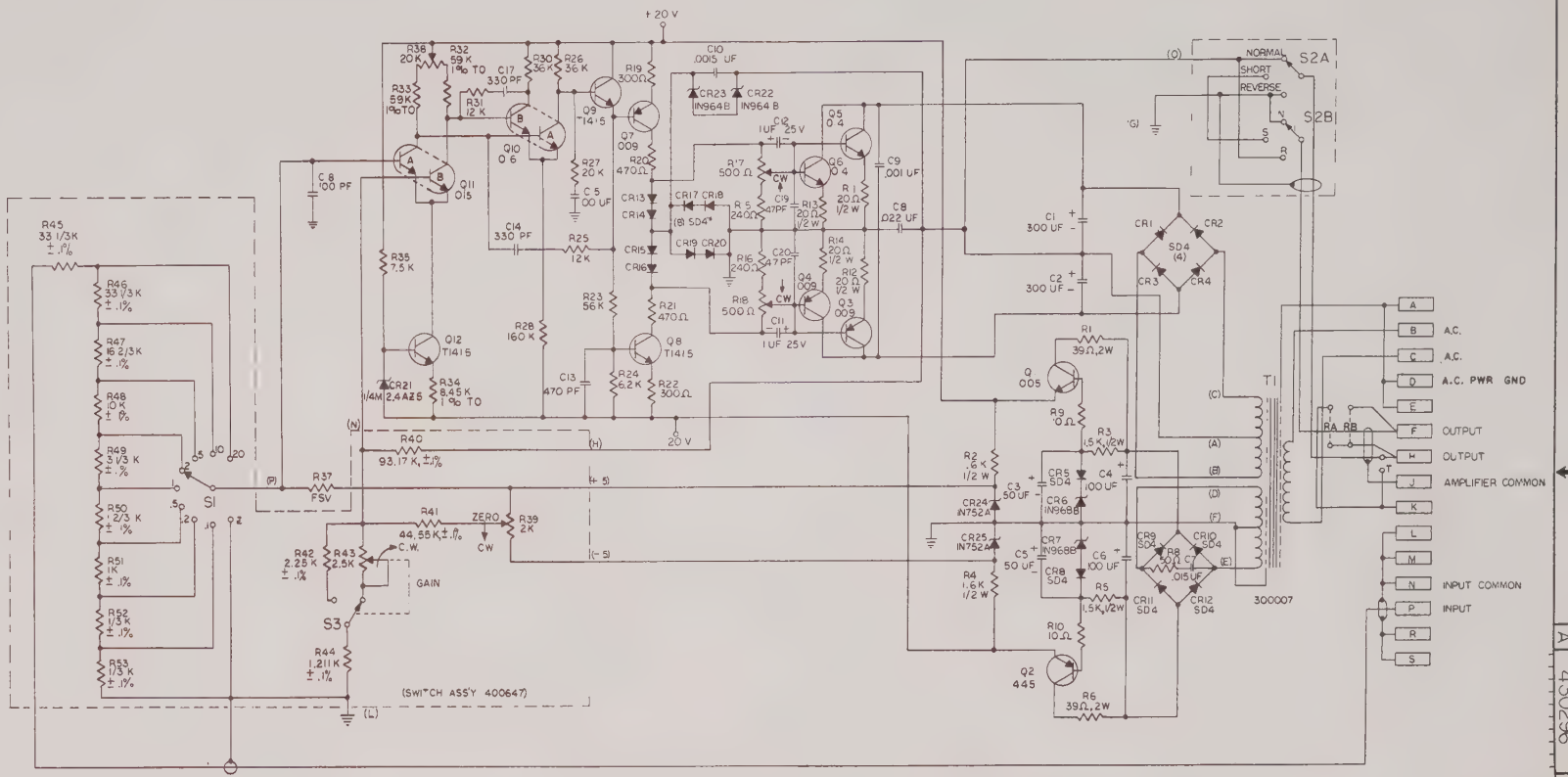
CODE IDENT NO. —— | SIZE D | 450907

SCALE NONE | WEIGHT —— | SHEET 1 OF 1

NOTES:

DANA-09 LISTS 1000 TOPYLIGHT 6-65

450907



LAST REF DES	DES NOT USED
R53	C16
CR25	R7
C20	R29
Q12	R36
S3	

2. LETTERS & NUMBERS IN PARENTHESES IDENTIFY BOARD CONTACTS FOR INTERCONNECTING WIRING.
1. RESISTORS TO BE 1/4 W, ± 5% CARBON.

NOTES UNLESS OTHERWISE SPECIFIED

QTY REQD	SYM	ITEM NO.	GOVT IDENT NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	SPECIFICATION

LIST OF MATERIALS OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS X ± .030 XX ± .020 XXX ± .010 ANGLES ± 0° 30'

DRAWN W. EDIE 14 Aug 1965
CHECK
ENGR
APPR
APPROVED
APPROVED

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC - 2720

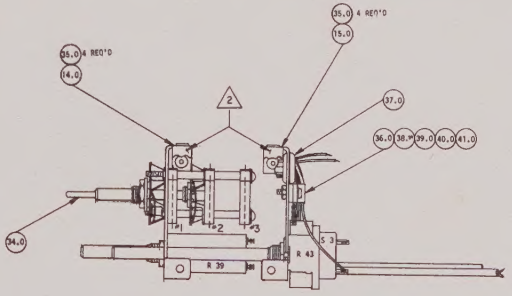
400646	2720	REF	REF
NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY

MATERIAL
APPLIED FINISH
APPLICATION QTY REQD

SYMBOLS
APPLICABLE TO DANA LABORATORIES INC. ONLY
SA — SUB-ASSY MRA — MAJOR REP. ASSY
MA — MODULE ASSY CA — COMPLETE ASSY

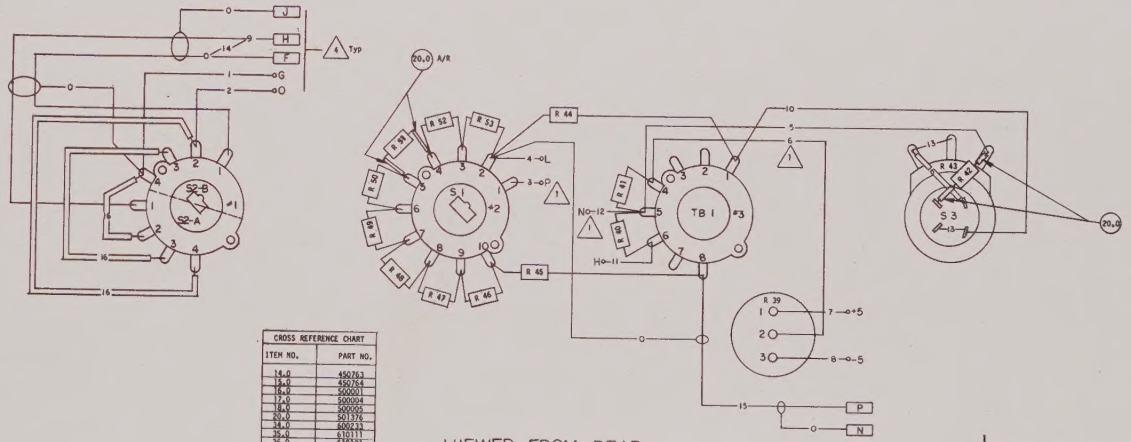
CODE IDENT NO. — SIZE D 430296 A
SCALE — WEIGHT — SHEET 1 OF 1

A 430296



TB 1		
S 2	34.0	Switch-Rotary
S 1		
R 53	3.0	1/3 K ,1%
R 52	3.0	1/3 K ,1%
R 51	2.0	1 K ,1%
R 50	5.0	1 2/3 K ,1%
R 49	6.0	3 1/3 K ,1%
R 48	1.0	10 K ,1%
R 47	7.0	16 2/3 K ,1%
R 46	8.0	33 1/3 K ,1%
R 45	8.0	33 1/3 K ,1%
R 44	4.0	1,211 K ,1%
R 43	13.0	POT 2.5 K & Switch
R 42	11.0	2.25 K ,1%
R 41	9.0	44.55 K ,1%
R 40	10.0	93.17 K ,1%
R 39	12.0	POT 2 K, 10 Turn
REF DES	B/M ITEM	DESCRIPTION

WIRE COLOR CHART		
WIRE NO.	COLOR	ITEM NO.
0	BLACK	22.0
1	WHT-BRN-BRN	23.0
2	WHT-BRN-RED	24.0
3	WHT-BRN-ORG	25.0
4	WHT-BRN-YEL	26.0
5	WHT-BRN-GRN	27.0
6	WHT-BRN-BLU	28.0
7	WHT-BRN-VIO	29.0
8	WHT-BRN-GRY	30.0
9	WHITE	----
10	WHT-RED-BLK	31.0
11	WHT-RED-RED	32.0
12	WHT-RED-ORG	33.0
13	BUSS WIRE	17.0
14	TWST SHLD PR	19.0
15	RG 174/U	21.0
16	SLVD BUSS WIRE	17.0 &20.0



VIEWED FROM REAR

CROSS REFERENCE CHART	
ITEM NO.	PART NO.
16.0	450762
34.0	450764
16.0	500001
17.0	500004
18.0	500005
20.0	501376
19.0	600233
35.0	610111
36.0	610187
37.0	611337
38.0	613043
39.0	613064
40.0	613077
41.0	617102

4. Letter indicates(-o) eyelets and ⊟ connector fingers identified on P. C. Board.

3. Dress shielded wire with shrinkable tubing (Item 16.0) at switch only.

2. Ho press nut on top tab nearside (Both brackets)

1. All hookup wires feed thru grommet except 3, 6, 12

NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD	SYM	ITEM NO.	GOV'T OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

MATERIAL

APPLIED FINISH

HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS | ANGLES
.X ± .030 | ± 0° 30'
.XX ± .020
.XXX ± .010
FORMED ANGLES ± 1.0°
ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR.
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS MIL-D-1000 AND MIL-D-70327

CONTRACT NO.

	NAME	DATE
DR		11-17-65
CHK		11-19-65
APPD		11/19/65

Rel 12-1-65
DEV # 209

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SWITCH ASSY — 2720

SIZE	CODE IDENT NO.	DWG NO.	
D		400647	A

SCALE | WT | SHEET 1 OF 1

REF DES	B/M ITEM	DESCRIPTION
C 14	21	330 pf
C 13	24,5	470 pf
C 12	28	1 MFD, 25 V
C 11	28	1 MFD, 25 V
C 10	31	.0015 MFD, 100 V
C 9	23	.001 MFD
C 8	30	.022 MFD, 100 V
C 7	29	.015 MFD, 100 V
C 6	26	100 MFD, 50 V
C 5	25	50 MFD, 25 V
C 4	26	100 MFD, 50 V
C 3	25	50 MFD, 25 V
C 2	27	300 MFD, 50 V
C 1	27	300 MFD, 50 V
CR 5	36	SD 4
CR 4	36	SD 4
CR 3	36	SD 4
CR 2	36	SD 4
CR 1	36	SD 4

MP MASTER
MA31120